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Technical Report

Weld overlay cladding of high strength low alloy steel with austenitic stainless steel – Structure and properties

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ABSTRACT

The present work aims at studying structure–property correlations in a weld overlay clad high strength low alloy steel with austenitic stainless steel of American Institute for Steel and Iron (AISI) 347 grade. Optical microscopy studies revealed that the interface between the two steels was nearly flat. The base plate had ferrite plus bainite microstructure adjacent to the interface and tempered bainite/martensite structure away from the interface. Grain coarsening and decarburization were observed near the interface. The stainless steel exhibited austenite dendritic structure. Tensile strength, notch-tensile strength and charpy impact energy of the base plate were found to be higher than those for the interface. The microhardness was observed to be maximum on the clad layer near interface. The shear bond strength of the weld overlay-interface was higher than the shear strength of the base plate. Fractography was carried out using scanning electron microscope on tensile, notch-tensile and shear bond test specimens of the interface as well as shear test specimens of the base plate. It revealed the presence of predominantly dimpled rupture. Charpy impact specimens of the interface failed in mixed mode while impact specimens of the base plate failed in ductile mode. Electron probe microanalysis across the bond interface indicated linear change in concentrations of Cr, Ni, Mn, Cu, Mo, Nb and Si between the levels appropriate to the clad layer and base metal.

1. Introduction

A weld overlay is defined as the deposit of a dissimilar weld metal laid on the surface of a metal part. The technique of weld overlay is an excellent method to impart properties to the surface of a substrate that are not available from that base metal. The term weld overlay, also known as weld cladding, usually denotes the application of a relatively thick layer (3 mm or more) of weld metal to impart a corrosion-, erosion-, or wear-resistant surface. A weld deposit of stainless steel laid on the surface of a low alloy steel for improved corrosion resistance is an example of a weld overlay. In addition to weld overlays that develop a composite structure by a fusion welding process, there are many processes such as roll cladding, explosive cladding, sheet and strip liner cladding, braze cladding and thermal spraying, by which composite structures may be produced [1]. Weld cladding may be accomplished by any one of the welding processes such as gas metal arc welding (GMAW), flux cored arc welding (FCAW), shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), plasma arc welding (PAW) and electroslag welding (ESW).

All metals that are used for welding fillers can also be used for weld overlay. With the exception of simple buildup situations, where the overlay is used to restore the original dimensions of a worn or corroded part, the composition and properties of the filler metal are often quite different from the base metal. The weld overlay cladding techniques were originally developed at Strachan & Henshaw, Bristol for use on Defence (Navy) components where the equipment must work in seawater with minimum maintenance and be subjected to extreme pressure and shock loading. Various parts of the submarine pressure hull such as sealing faces of the rectangular door and the circular door, the shafts and arms forming the hinges to carry the doors, and the mating faces on the main component body were clad with Inconel 625 [2]. In recent years, weld cladding processes are applied in numerous industries such as chemical, fertilizer, nuclear and steam power plants, food processing, and petrochemical industries.

Various materials such as nickel and cobalt alloys, copper alloys, manganese alloys, alloy steels, ceramics and composites are used for weld overlay applications [1]. Pan and Chen have deposited high hardness maraging steel on 16Mn steel and 9Cr steel to improve the hardness, wear resistance and crack resistance [3]. Microstructure and wear properties of Fe–Mn–Cr–Mo–V alloy cladding by submerged-arc welding on AISI 1045 steel substrate were studied by Lu et al. [4]. Goodwin carried out weld overlay cladding with iron aluminides to improve the corrosion and erosion resistance of 2¼Cr–1Mo steel, 310 stainless steel and Inconel 600 [5]. The effect of process parameters on clad bead geome-

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